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METHOD FOR REMOVING COPPER FROM STEEL SCRAP

[Hagane sucurappu kara no akagane jokyo houhou]

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Claims

1. A method for removing copper from steel scrap, characterized by comprising a combination of a first step involving selectively isolating material containing copper from a batch of steel scrap, a second step involving heating the selected material in molten flux and dissolving the copper so that it is transferred to the flux layer, and a third step involving isolating the material containing copper from the molten flux.

2. The method for removing copper from steel scrap according to Claim 1, characterized in that the first step is a method that involves detecting the difference in color between iron parts and copper parts in the scrap by image analysis, thereby automatically detecting scrap with copper at its surface, and selectively isolating [the material] based on the result.

3. The method for removing copper from steel scrap according to Claim 1, characterized in that the first step is a method that involves heating the steel scrap, detecting the difference in temperature based on the difference in heat conductivity in the steel parts and copper parts, thereby automatically detecting parts containing copper, and selectively removing [the material] based on the result.

4. The method for removing copper from steel scrap according to Claim 1, characterized in that the flux that is used in the second step does not dissolve the copper to produce a uniform phase.

5. The method for removing copper from steel scrap according to Claim 1, wherein the flux used in the second step comprises three or more types selected from SiO_2, CaO, Al_2O_3, MnO, FeO, Na_2O, B_2O_3, CaF_2 and NaF.

6. The method for removing copper from steel scrap according to Claim 1, characterized by carrying out the treatment of the second step by connecting a vessel (1) containing preheated scrap with a vessel (2) that allows heating of flux, and transferring molten flux between the two vessels.

7. The method for removing copper from steel scrap according to Claim 1, characterized in that isolation of the copper in step 3 is carried out by utilizing specific gravity to deposit the parts containing copper from the molten flux.

8. The method for removing copper from steel scrap according to Claim 1, characterized by spinning the vessel containing the molten flux to accelerate isolation of the copper in the third step.

Detailed description of the invention

[0001]

Industrial application field

The present invention relates to a method whereby steel scrap containing copper is treated and the copper parts are separated and removed, thereby reducing the copper content of the steel scrap and recovering the isolated copper.

[0002]

Prior art

In recent years, the number of parts composed of combinations of copper with iron and steel material has increased in automobiles and household electrical devices, and the Cu content of scrap has increased, on average. When the copper content of scrap increases as a result of melting the metal without treatment, there are strong adverse influences on the hot workability of the steel material.

[0003]

In the past, separation of parts containing copper has involved mechanical separation of individual materials, and this separation has been carried out using visual and manual operations. However, it will

be increasingly difficult to continue to maintain a labor force for these types of operations. A practical method for automatically selecting parts containing copper has not been established. Moreover, there are currently no practical methods for the effective utilization of parts containing copper, even if automated selection of these parts were possible.

[0004]

A number of ideas and investigations have been proposed in regard to methods for separating copper from scrap. Among these, a method is known in which sulfide is used as a material whereby the copper is dissolved/separated in the flux through a chemical reaction. However, this method has a high copper distribution ratio of about 20, and there have been economic problems with flux costs and heat loss with methods involving treating molten material and then discharging the flux from the system. One means for resolving this problem has been a method in which, rather than being dissolved, the scrap is treated with a sulfide-based flux in a first operation but in this case, when the treated scrap is subsequently melted with the sulfide flux adhered, the sulfur is carried into the melting furnace. Consequently, there are problems with contamination of the metal with sulfur and the generation of sulfur gas during melting. In addition, it is necessary to remove copper in order to recycle and use the flux containing the copper. However, it is currently difficult to remove the copper that is dissolved in the flux through chemical reactions without separating the sulfur.

[0005]

In addition, a method has been offered that involves dissolving copper in a material that dissolves copper such as lead or aluminum, then isolating the material from the scrap. However, it is not easy to separate the dissolved copper for recycling and reuse. Moreover, methods have been proposed whereby

the copper is heated along with the scrap to a temperature that is at or above the melting point of copper, whereupon the copper is then separated. However, separation of copper and iron from a three-component system consisting of high-temperature atmosphere, solid iron and molten copper is not easy due to environmental restrictions.

[0006]

In light of the above state of affairs, at present, there are no practical methods for effectively separating copper other than methods involving visual identification and manual operations carried out at normal temperatures.

[0007]

Problems to be solved by the invention

In light of the above state of affairs, an object of the present invention is to provide an economical method whereby copper is separated from scrap containing copper, the copper is separated and recovered from the flux containing the copper, the flux is reused, and the flux that has affixed to the scrap does not cause problems, even when carried over into the melting furnace.

[0008]

Means to solve the problems

The above problems can be resolved by the method described below.

(1) A method for removing copper from steel scrap, characterized by comprising a combination of a first step involving selectively isolating material containing copper from a batch of steel scrap, a second step involving heating the selected material in molten flux and dissolving the copper so that it is

transferred to the flux layer, and a third step involving isolating the material containing copper from the molten flux.

[0009]

(2) The method for removing copper from steel scrap according to (1), characterized in that the first step is a method that involves detecting the difference in color between iron parts and copper parts in the scrap by image analysis, thereby automatically detecting scrap with copper at its surface, and selectively isolating [the material] based on the result.

(3) The method for removing copper from steel scrap according to (1), characterized in that the first step is a method that involves heating the steel scrap, detecting the difference in temperature based on the difference in heat conductivity in the steel parts and copper parts, thereby automatically detecting parts containing copper, and selectively removing [the material] based on the result.

[0010]

(4) The method for removing copper from steel scrap according to (1), characterized in that the flux that is used in the second step does not dissolve the copper to produce a uniform phase.

(5) The method for removing copper from steel scrap according to (1), wherein the flux used in the second step comprises three or more types selected from SiO_2, CaO, Al_2O_3, MnO, FeO, Na_2O, B_2O_3, CaF_2 and NaF.

[0011]

(6) The method for removing copper from steel scrap according to (1), characterized by carrying out the treatment of the second step by connecting a vessel (1) containing preheated scrap with a vessel (2) that allows heating of flux, and transferring molten flux between the two vessels.

(7) The method for removing copper from steel scrap according to Claim 1, characterized in that isolation of the copper in step 3 is carried out by utilizing specific gravity to deposit the parts containing copper from the molten flux.

[0012]

(8) The method for removing copper from steel scrap according to (1), characterized by spinning the vessel containing the molten flux to accelerate isolation of the copper in the third step.

[0013]

Operation

The present invention is described in detail below using specific practical methods. It is an essential characteristic of the present invention that it involves a combination of a step whereby steel scrap containing copper is heated in a flux to dissolve the copper, which is then separated, and a step whereby the copper is separated and recovered from the molten flux containing the copper. Removal of the copper in this method is achieved by utilizing the different phases of the steel scrap and the copper or copper alloy, without the copper being dissolved in the steel. Consequently, in order to improve efficiency with this step, material containing copper is selected and separated from the steel scrap and then subjected to treatment. If this pretreatment is not carried out, then the following problems will arise from an industrial standpoint when performing the treatment described above. 1) The energy required

for scrap heating will increase, 2) flux consumption will increase in proportion to the flux that is affixed to the scrap and is carried into the melting furnace, and 3) the scrap that is treated by the method will, in principle, have to be introduced into the melting furnace in batches, since continuous introduction will not be appropriate.

[0014]

Selection and isolation of material including copper from the steel scrap batch can be carried out by the methods described below when the present invention is utilized as an automated method. First, the scrap batch is conveyed on a conveyor, the difference in color between parts containing iron and parts containing copper is detected by image analysis, and the scrap containing parts in which copper has been detected is automatically separated off from the line. Alternatively, a method may be used in which scrap that is carried on a conveyor is passed through a high-temperature heating furnace, whereupon the surface temperature distribution of the scrap is measured. The parts containing copper are detected and separated from the line utilizing the differential surface temperature resulting from differences in heat conduction between the copper parts and iron parts.

[0015]

The scrap containing copper that has been separated from the scrap component in this manner is then, for example, housed in a vessel for preheating, before being heated, for example, using a burner or the like. It is advantageous to carry out preheating, because the rate of copper dissolution in the subsequent step will be increased, thereby improving productivity. The preheated scrap is then immersed in a molten flux layer and is heated to a temperature that is at or above the melting point of copper, thereby melting the copper. In this case, it is preferable not to substantially dissolve the copper as a uniform

phase in the flux. This is because, even if this type of flux is carried into the melting furnace partially affixed to the scrap, there will be no contamination of the metal as occurs with sulfur-based flux. In addition, there will be minimal generation of undesirable gases, and copper resolution and recovery will be facilitated because the copper is not uniformly dissolved.

[0016]

Fluoride is added, as necessary, to the flux having an oxide as the primary component. Examples of oxides include SiO_2, CaO, FeO, Al_2O_3, MnO, Na_2O and B_2O_3. Examples of fluorides include CaF_2 and NaF, and three or more of these components may be used. These components are prepared so that the flux satisfies the parameters described below. 1) The melting point (solidification termination point) is 1100°C or less.

[0017]

In the present invention, the molten flux is used as a thermal medium for dissolving the copper without dissolving the steel. In addition, the flux has the function of producing a flow of molten flux in the vicinity of the steel scrap in order to separate the molten copper from the scrap. In order to perform this function, it is necessary for the melting point to satisfy the condition indicated above. 2) The dissolution level with respect to iron oxide is 26% or below.

[0018]

If the dissolution level with respect to iron oxide (FeO) is high, then the oxide skin formed on the surface of the steel scrap will dissolve, and the dissolved copper will be difficult to separate because it will affix to the steel surface. On the other hand, if the concentration of iron oxide dissolved in the flux

exceeds 26%, then the amount of flux that is affixed to the steel scrap will increase, which is undesirable. Consequently, the flux is prepared so that the dissolution level with respect to iron oxide is 26% or less, so that the copper is dissolved the flux while maintaining a condition whereby the iron oxide that is affixed to the surface of the steel is not completely dissolved.

[0019]

Steel scrap is subjected to a heat treatment in an oxidative atmosphere in order to improve the thermal economy and in order to produce an oxide skin on the surface that will prevent leakage of iron and copper. An example of a heating method involves using heat from a burner or using gas generated from the scrap melting furnace as fuel. In this case, the atmosphere will be completely combusted, leaving a free oxygen content of 1% or greater and a temperature of 800°C or greater.

[0020]

When the MnO content in the flux components is 10% or greater, the following two effects are produced: 1) the flux melting point decreases, and 2) the copper alloys with the Mn are reduced during heating in the vessel (2), thereby decreasing the melting point. Consequently, the operating temperature in the second step can be decreased by utilizing these two effects.

[0021]

An example of an embodiment involving the use of molten flux to treat copper scrap is presented in Fig. 1. A vessel (1) containing preheated scrap is linked with a vessel (2) that can heat the flux, and the molten flux is made to move between the vessels, for example, by varying the pressure in the vessel (2). In the vessel (2), the flux is electrically heated, for example, to a temperature of 1100°C or greater. The

parts of the vessel wall on which the flux has solidified assume a "self-lined" state. In addition, deposition and separation progress as a result of the different specific gravity of the aggregates of molten copper particles suspended in the molten flux during heating. The deposited copper is removed from the furnace by periodically opening the hole.

[0022]

When molten flux is transferred into the vessel (1), it comes into contact with iron scrap and heats it, resulting in dissolution of the copper parts which are transferred to the flux. By transferring the molten flux multiple times between the vessels (1) and (2) while supplying heat, removal of the molten copper is carried out. Upon completion of removal of the copper from the steel scrap, the molten flux is transferred to the vessel (2), the connection between the two vessels is broken, and the high-temperature steel scrap is introduced into a melting furnace where the steel scrap is heated to about 1100°C. Normally, handling is difficult because the scrap sticks together, but the present invention has the advantage that the scrap is readily treated, because the material is coated with flux.

[0023]

In addition to the method described above, the vessel containing the molten flux can be spun in order to promote separation by utilizing the difference in specific gravity of the copper and the flux, and centrifugal forces can thus be effectively utilized in the invention. The molten flux can thus be repeatedly used as described above.

[0024]

Application examples

1. As shown in Fig. 2(a), steel scrap (shredder scrap) was used, and coloration was detected at the surface of the copper in order to select out the material. The proportions and average contents for the selected and unselected materials are shown in Table 1.

[0025]

TABLE 1

	1 平均の銅含有量	重量比率 2
3 処理前の鋼スクラップ	0.57%	100
4 銅を伴うものとして選別されたスクラップ	1.26%	27
5 銅を伴うものを分離した後のスクラップ	0.31%	73

Key: 1 Average copper content

2 Weight ratio

3 Steel scrap prior to treatment

4 Scrap selected as material containing copper

5 Scrap remaining after separation of material containing copper

[0026]

2. The steel scrap was temporarily heated as shown in Fig. 2(b) (3 min at 500°C in a furnace), and the surface temperature was detected with a thermal viewer. Parts having temperatures that were 30°C higher than the average temperature were detected and assumed to have copper at the surface. The scrap

was thus selected on the basis of this temperature differential. The proportions and average contents for the selected and unselected materials are shown in Table 2.

[0027]

TABLE 2

1	平均の銅含有量	重量比率 2
3 処理前の鋼スクラップ	0.57%	100
4 銅を伴うものとして選別されたスクラップ	1.39%	24
5 銅を伴うものを分離した後のスクラップ	0.31%	76

Key: 1 Average copper content

2 Weight ratio

3 Steel scrap prior to treatment

4 Scrap selected as material containing copper

5 Scrap remaining after separation of material containing copper

[0028]

Parts containing copper were selected in both Application Examples 1 and 2, but somewhat more efficient selection was seen with the method of Application Example 2.

3. The scrap selected in Application Example 2 (with affixed copper) was held in a preheating vessel and heated with a burner, thereby producing a free oxygen level of 2%, a maximum heating temperature of 950°C, and an average heating temperature of 840°C. In this case, the oxidation occurring in the steel scrap was about 3.4%.

4. The preheated scrap was transferred into each vessel and placed as shown in Fig. 1. The molten flux that was heated using a graphite electrode was then repeatedly supplied and removed by changing the pressure of the vessel (2). The operating conditions and the results are shown in Table 3.

[0029]

TABLE 3 /5

		1 実施例A	B	C	D
2 フラックス組成	SiO_2	35	40	30	45
	CaO	23	28	10	31
	Al_2O_3	6		8	
	MnO	15	15	25	
	FeO		3		
	Na_2O	15			
	B_2O_3			5	
	CaF_2			15	
	NaF		10		16
3 容器2内のフラックス温度		1190℃	1160	1090	1140
4 スクラップ予熱温度		780℃	820	790	980
5 処理時間		27分	19	16	13
6 平均の銅除去率		55%	52	44	54
7 スクラップへのフラックス除去率		1.2kg/t	0.6	0.9	0.7

Note:

Scrap preheating temperature: Average scrap temperature prior to the second step

Flux removal rate from scrap: Flux removal rate per ton of scrap

Average copper removal rate: Removal rate before and after the second step

Key: 1 Application Example A

2 Flux composition

3 Flux temperature in vessel (2)

4 Scrap preheating temperature

5 Treatment time

6 Average copper removal rate

7 Flux removal rate in scrap

[0030]

In the present invention, almost no dissolution of copper in the flux as a uniform phase was ensured in the following manner. Specifically, by finely grinding a rapidly-solidified flux layer and carrying out separation based on specific gravity, most of the copper was present as metal particles as shown in Table 4, with only a very small amount dissolved uniformly in the flux.

[0031]

TABLE 4

1	急速凝固させたフラックス平均銅含有量	4.5%
2	微粉砕して比重選別して比重が大きい部分を除去したあとの部分の平均銅含有量	0.02%

Key: 1 Average copper content in rapidly-solidified flux

2 Average copper content of part after removal of high-specific gravity content through fine grinding and specific gravity selection.

[0032]

The results shown in Table 5 were obtained upon extraction and analysis of the copper component accumulating at the bottom of vessel (1) and vessel (2). This material was then subjected to a melting

step, and common processes were used to separate out the iron and manganese, thereby producing metallic copper.

[0033]

TABLE 5

Cu	Fe	Mn
79%	3%	18%

(Case C in Table 3)

[0034]

Although maintained only for copper particle separation, approximately 30 min was required for the average copper concentration in the melted flux to reach 0.5% or less. In order to shorten this time, a separate vessel containing molten flux was rotated at 50 rpm. As a result, the average copper concentration could be decreased to 0.5% or less after 5 min. The copper concentration decreased to 7% of the amount prior to rotation.

[0035]

Effect of the invention

As described above, by implementing the present invention, it is possible to effectively remove copper from steel scrap and to separate and recover the copper, which provides significant industrial and economic benefits.

Brief description of the drawings

Figure 1 is an example of an embodiment of the second step of the present invention.

Figure 2 is an example of an embodiment of the first step of the present invention.

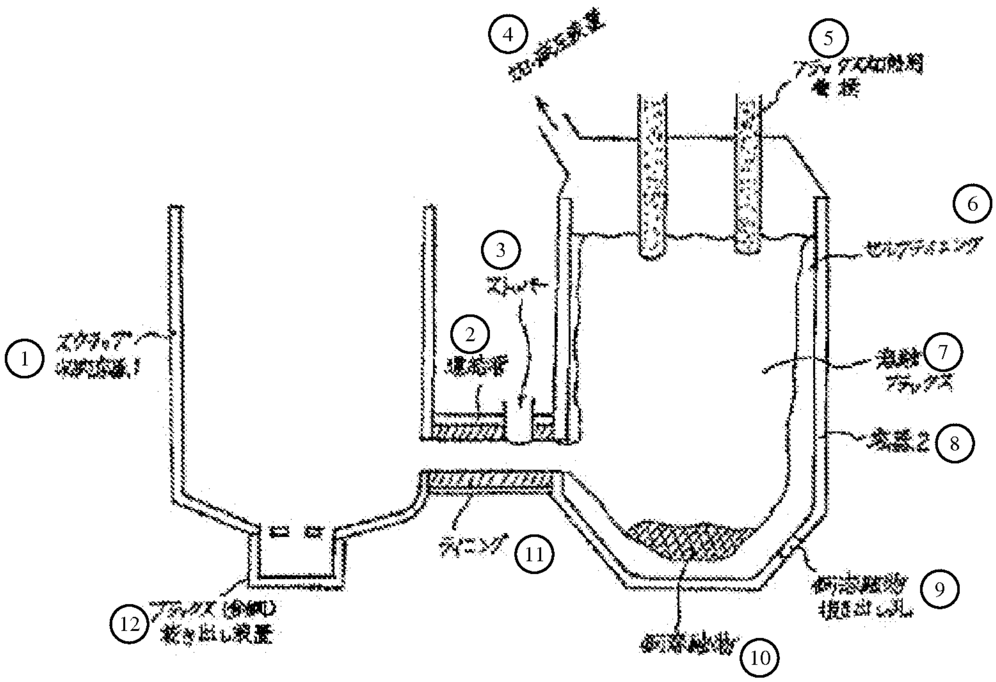

Figure 1

Key: 1 Scrap [illegible] vessel (1)

2 Connection tube

3 Stopper

4 Compression/evacuation device

5 Flux heating electrode

6 Self-lining

7 Molten flux

8 Vessel (2)

9 Molten copper material extraction hole

10 Molten copper

11 Lining

12 Flux (copper-containing) extraction device

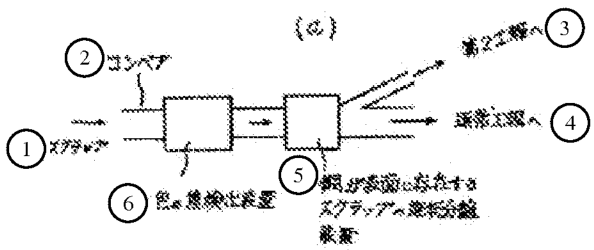

Figure 2(a)

Key: 1 Scrap

2 Conveyor

3 To second step

4 To standard steps

5 Continuous separation device for scrap with copper at surface

6 Color differential detection device

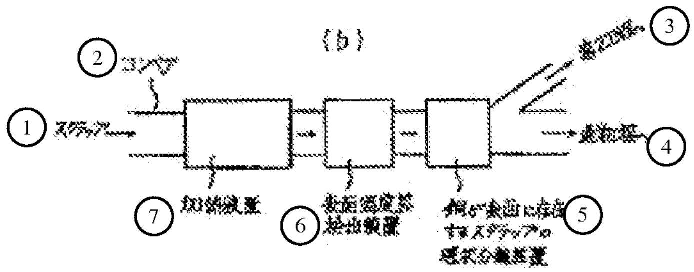

Figure 2(b)

Key:

1	Scrap
2	Conveyor
3	To second step
4	To standard steps
5	Continuous separation device for scrap with copper at surface
6	Surface temperature differential detection device
7	Heating device